on layer depth could be obtained if other radar systems, working at different wavelengths, could be used in the same type of experiment. Similar observations could be made on some of the near planets in order to gain further insight into their surface characteristics or possibly their atmospheres.

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Mars: Compatible Determinations of Surface Pressure through Particle Scattering

Abstract. *The number of scattering particles required to bring the visual polarimetric and ultraviolet photometric estimates of the surface pressure of Mars into agreement are calculated. Concentrations of 10^8 to 10^9 ice particles, 0.2 micron in diameter, per square-centimeter column are obtained. Based on concentrations of Aitken nuclei in the atmosphere of Earth, a layer less than 100 meters thick would contain the required number of particles. The compatible pressures obtained in this manner for various N_2–CO_2 and Ar–CO_2 atmospheric models lie within the range of pressures determined spectroscopically.*

The interpretation of recent spectroscopic observations of the $5\nu_3$ band of CO_2 in the Martian atmosphere has suggested surface pressures far lower than the generally accepted value of 85 or 90 mb determined polarimetrically by Dollfus (*1*) and supported by the photometry of de Vaucouleurs (*2*). An upper limit for the surface pressure, based on ultraviolet photometry from the ground (*3*), lies between these values.

The discrepancies among these results and the design-data requirements for spacecraft entering the Martian atmosphere stimulated a great deal of new work on the problem of the surface pressure, including critical reviews by Chamberlain and Hunten (*4*) and by Cann, Davies, Greenspan, and Owen (*5*). The latter review considered the visual polarimetric measurements of Dollfus (*1*) and an ultraviolet photometric estimate by Musman (*3*), in addition to various pressure determinations from the spectroscopic observations by Kaplan, Münch, and Spinrad (*6*).

The polarimetric technique involves separation of the atmospheric brightness $B_a°$ and surface brightness $B_s°$ at the center of the disk on the basis of differences in polarizing characteristics. The absolute atmospheric brightness at 6100 Å is then determined from the ratio $B_a°/B_s°$ and from independent photometric observations of $B_s°$. The pressure is estimated from Rayleigh scattering theory; a pure molecular atmosphere with scattering and polarizing properties similar to those of air is assumed. Dollfus (*1*) obtained a brightness ratio ($B_a°/B_s°$) of 0.028 and a pressure of 90 mb. During the review of the polarimetric work (*5*) it was found that Dollfus (*1*) unnecessarily separated the phase and zenith-angle dependence of polarization. Reexamination of the data without separating variables yielded a revised value for the brightness ratio of 0.015 which, when coupled with more recent photometric results, gave a pressure estimate of 61 mb for a nitrogen atmosphere. Atmospheres consisting of two constituents were considered, and it was found that the visual pressure determination P_v could be expressed as:

$$P_v = \left(\frac{B_a°}{B_s°}\right)\left(\frac{B_s°}{B_s}\right)\frac{4\,\bar{p}_v g}{A_0 p\,(\cos 0)} \times \left[\frac{xM_1 + (1-x)M_2}{x\sigma_1^{v} + (1-x)\sigma_2^{v}}\right]$$

where ($B_a°/B_s°$) is the ratio of atmospheric to surface brightness at the center of the Martian disk at 6100 Å; ($B_s°/B_s$) is the ratio of the brightness of the center of the disk to the brightness of the entire disk; $\bar{p}_v = \pi B_s/E$ is the monochromatic geometric albedo at 6100 Å, where E is the monochromatic solar flux; g is the gravitational force per unit mass on Mars; $p(\cos 0)$ is the Rayleigh phase function for backscattering; A_0 is Avogadro's number; M_1 and M_2 are the gram molecular weights of the two constituents; σ_1^{v} and σ_2^{v} are the Rayleigh scattering cross sections per molecule for the two constituents at 6100 Å; and x is the fraction of molecules or atoms of constituent 1.

The estimate made by ultraviolet photometry (*3*) is based on the assumption that, because of the low surface albedo, the entire brightness of Mars at 3300 Å is due to atmospheric scattering. This estimate is necessarily an upper limit in the absence of absorption. This was pointed out by Musman (*3*), who matched the reflectivity of Mars at 3300 Å with model Rayleigh atmospheres and obtained an optical thickness of 0.058. This optical thickness corresponds to a surface pressure of 27 mb for a nitrogen atmosphere. For a two-constituent atmosphere, the ultraviolet pressure determination P_{uv} can be expressed as:

$$P_{uv} = \frac{\bar{p}_{uv} g}{0.794\,A_0}\left[\frac{xM_1 + (1-x)M_2}{x\sigma_1^{uv} + (1-x)\sigma_2^{uv}}\right]$$

where $\bar{p}_{uv} = \pi B_a/E$ is the monochromatic geometric albedo at 3300 Å; 0.794 is a factor containing the phase function and a correction for the sphericity of the atmosphere; and σ_1^{uv} and σ_2^{uv} are Rayleigh scattering cross sections per molecule for the two constituents at 3300 Å. The results obtained by this formulation are in agreement with Musman's determination (*3*).

In both of these techniques only molecular scattering is assumed for the

Table 1. Compatible visual and ultraviolet determinations of the surface pressure of Mars.

Atmospheric composition (%)			Pressure (mb)		$\mathcal{N}_c$*	Compatible pressure (mb)
N_2	CO_2	Ar	Visual determination	Ultraviolet determination	(10^8)	
100			61	27	6.3	24
75	25		54	24	6.2	22
50	50		48	21	6.2	19
25	75		45	20	6.2	18
	100		42	19	6.2	17
	75	25	48	21	6.2	20
	50	50	57	25	6.2	22
	25	75	71	32	6.1	29
		100	94	43	6.1	39

* Number of particles, 0.2 μ in diameter, per square-centimeter column required for compatibility.

observed atmospheric brightness B_a. If particles exist in suspension in the atmosphere, the observed brightness will be

$$B_a = B_m + B_p$$

where B_m and B_p are the brightnesses produced by molecules and particles, respectively. If the particles are smaller than about 0.2 μ in diameter, they will have visual polarizing properties similar to molecules and will not be detectable in the polarimetric studies. They may still, however, contribute significantly to the brightness. It is important to note that consideration of this restricted class of particles limits the physical validity of this calculation. This restriction is necessary, however, since the brightnesses are additive only when the polarization characteristics of the particles match those of the molecules. This has also been demonstrated by Rea and O'Leary (*7*).

Only the molecular brightness B_m should be included in the visual and ultraviolet pressure determinations. Thus, correction of the above expressions for the effect of particle scattering involves the subtraction of the particle brightness B_p from the observed brightness B_a; that is, replacement of B_a by $(B_a - B_p)$. The presence of $\mathcal{N}$ particles per square-centimeter column will (at opposition) produce a brightness (*8*)

$$B_p = \frac{E\,\lambda^2}{8\pi^2}\,\mathcal{N} i_o$$

where E is the incident solar flux, λ is the wavelength, and i_o is the Mie backscatter coefficient. Incorporation of this correction in the previous expressions yields

$$P_v = \left(\frac{B_s^o}{B_s}\right) \frac{4\,\bar{p}_v g}{A_o p\,(\cos 0)} \times \left[\frac{xM_1 + (1-x)M_2}{x\sigma_1^{v} + (1-x)\sigma_2^{v}}\right] \left[\left(\frac{B_a^o}{B_s^o}\right) - \frac{\lambda^2 \mathcal{N} i_o^{v}}{8\pi\bar{p}_v}\right]$$

and

$$P_{uv} = \frac{g}{0.794}\left[\frac{xM_1 + (1 - xM_2}{x\sigma_1^{uv} + (1-x)\sigma_2^{uv}}\right] \times \left[\bar{p}_{uv} - \frac{\lambda^2 \mathcal{N} i_o^{uv}}{8\pi}\right]$$

for the visual and ultraviolet estimates in the presence of $\mathcal{N}$ particles per square-centimeter column. The terms on the far right of each expression represent the molecular brightness $B_m = B_a - B_p$.

The obvious question arose as to whether the effect of some abundance $\mathcal{N}_c$ of particles could bring the visual and ultraviolet determinations into agreement. Setting P_{uv} equal to P_v, we obtain the particle abundance $\mathcal{N}_c$ per square-centimeter column which will reduce the visual and ultraviolet pressure determinations to an identical value. The substitution of $\mathcal{N}_c$ into the expression for either the visual or the ultraviolet pressure determination yields the compatible pressure (in millibars)

$$P = 3.94 \times 10^{-27}\left[\frac{xM_1 + (1-x)M_2}{x\sigma_1^{v} + (1-x)\sigma_2^{v}}\right] \times \left[1.50 - 7.28\left\{\frac{5.91 - 35.4\,\Sigma}{28.7 - 3.41\,(i_o^{uv}/i_o^{v})\Sigma}\right\}\right]$$

where the numerical values are determined from parameters listed previously (*5*). Here the quantity in curved brackets is proportional to $\mathcal{N}_c$ and

$$\Sigma = \left[\frac{x\sigma_1^{v} + (1-x)\sigma_2^{v}}{x\sigma_1^{uv} + (1-x)\sigma_2^{uv}}\right].$$

The ratio (i_o^{uv}/i_o^{v}) has been estimated from Penndorf's results (*8*) for ice particles. For ice particles 0.2 μ in diameter, $i_o^{uv} \sim 0.15$ and $i_o^{v} \sim 0.02$. The ratio $(i_o^{uv}/i_o^{v}) \sim 7.6$ holds over a fair range of particle sizes. Hence the compatible pressure may not depend critically on particle size (in this restricted size range) and would be valid for a distribution of particle sizes. The number of particles required for a compatible pressure would, however, be strongly dependent on the size parameter. Table 1 gives the compatible pressures for several N_2–CO_2 and Ar–CO_2 atmospheres with the number $\mathcal{N}_c$ of 0.2 μ-diameter ice particles per square-centimeter column required for compatibility. Also included are the visible and ultraviolet determinations calculated in the absence of particles.

It should be noted that the ratio of σ^{v}/σ^{uv} for CO_2, N_2, and Ar are approximately equal, so that the values of Σ and hence $\mathcal{N}_c$ are nearly independent of the relative amounts of the two constituents in either the N_2–CO_2 or the Ar–CO_2 atmospheres. The concentration of CO_2 in the Martian atmosphere is most likely greater than 25 percent. Compatible pressures are therefore in the range 17 to 29 mb; these pressures agree quite well with the spectroscopic determinations, which lie in the range 10 to 40 mb.

The ultraviolet determination represents an upper limit because the surface albedo is assumed to be zero. Consideration of finite surface reflectivity at 3300 Å increases $\mathcal{N}_c$ and reduces the estimates of ultraviolet and compatible pressure.

Currently, spectroscopic pressure estimates at the low end of the quoted range are in favor. The reduction of the 94-mb estimate (for 100 percent Ar) to the 10-mb level requires only 9.2×10^8 particles per column. Thus, reasonable particle concentrations can account for a wide range of discrepancies in the polarimetric and photometric determinations.

Condensation nuclei (Aitken nuclei), whose size range embraces the value of 0.2 μ diameter considered here, are commonly found in concentrations of $10^5/cm^3$ in the atmosphere of Earth. Thus, a particle layer less than 100 meters thick would produce the effect described above. Rea has shown (*9*) that silicate particles of such size would require months to settle from 6 km altitude in a typical Martian atmosphere.

My treatment is not meant to indicate that the derived compatible pressures are accurate representations of the conditions on Mars, but rather that the presence of a reasonable number of particle scatterers in suspension can bring the visible and ultraviolet determinations into agreement with each other and with the spectroscopic estimates which do not suffer from this uncertainty. Absorption, forward scattering of surface-reflected radiation, and scattering by large particles have been neglected, as in previous work. This fact should be kept in mind when the utility of photometric and polarimetric data for atmospheric pressure determinations is considered. A great deal of analytical and experimental work will be required before these complex problems in real atmospheres are understood.

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Gamma-Globulin Factors (Gm and Inv) in New Guinea: Anthropological Significance

Abstract. *Analysis of the hereditary Gm and Inv γ-globulin factors of 1669 New Guineans from the Morobe and Eastern Highlands districts and Bougainville Island demonstrates that the frequencies of the three Gm alleles present* (Gm^a, Gm^{ab}, *and* Gm^{ax}) *are similar in general to those in Mongoloids and in particular to those in Southeast Asians and Micronesians. The New Guinea frequencies are distinct from those in other populations, including Australian aborigines. Highly significant differences in frequencies of Gm and Inv alleles occur between Melanesian- and non-Austronesian-speaking New Guineans.*

Several alleles at each of two loci (Gm and Inv) produce a series of antigens on the IgG immunoglobulin molecules of man. The frequencies of the antigens differ among populations (as do those of the red-cell blood group systems) and are inherited by means of different alleles in different populations. Both characteristics make these antigens of great interest to anthropologists, particularly because the population differences coincide remarkably well with traditional major racial groupings. Only in Caucasians, for example, does Gm(a) vary from 100 percent, while Negroids alone lack Gm(x) and show Gm(c). The allele Gm^{ab} is present in Mongoloids and Negroids but is absent among Caucasians (*1*). Since the number of studies on noncosmopolitan peoples is severely limited, the analyses, given in this report, of the Gm and Inv determinations on 1669 serum samples from individuals in the Australian Trust Territory of New Guinea provide initial data for an anthropologically important area.

During 1962–63 blood samples and anthropometric, dermatoglyphic, and genealogical data were collected from 3100 New Guineans residing in an area of the Morobe and Eastern Highlands districts. The area measures about 100 by 125 km and extends northwest from Lae at the mouth of the Markham River. Data were also collected from 183 New Guineans from villages near Kieta, Bougainville Island. The blood samples were refrigerated and flown to Sydney, where the serum was separated and sent to Melbourne. At the end of the fieldwork 1669 serum samples were transferred to Cleveland and were typed for Gm and Inv factors by established methods (*1–3*).

The indigenous unit of orientation, the village, was used as the initial unit of analysis. The New Guinea villages sampled range in population from under 100 to several hundreds and in altitude from sea level to approximately 1500 m. Village life retains its indigenous character, including dependence on a horticultural technology, to a very large degree; however, villages near Lae, an administrative center, and on the two roads to the town, as well as those on Bougainville, are participating increasingly in a market economy. Villages are characterized by a remarkable degree of cultural autonomy and diversity, as evidenced most strikingly by the approximately 500 languages recognized in the Territory and in West Irian.

The villages tested in the Markham Valley region were chosen in order to take maximum advantage of the cultural and ecological variation manifested even in this restricted area. The two major linguistic stocks in the Territory, Melanesian (MN) and non-Austronesian (NAN), are roughly equally represented. Although MN-speaking groups are generally found in coastal areas, mountain and valley villages of both linguistic stocks have been included. Three villages (Nos. 19, 20, and 21 in Tables 1 and 2) belong to the NAN Gadsup-Auyana-Awa-Tairora linguistic family of the East New Guinea Highlands Stock (*4*), whereas three other NAN-speaking mountain villages, Waigwanom, Tapakanantu, and Gwasiram, are part of the ill-defined cultural complex called Kukukuku (No. 22). Two NAN-speaking villages on the edge of the Saruwaged Range, Mamamban and Narumonke (Nos. 17 and 18), are separated from the other NAN samples by the MN-speaking villages of the Markham Valley. The majority of the remaining villages speak the MN language Atsera including its dialects. In some cases neighboring and highly intermarried villages have been combined for analysis; for example, the three Nasioi-speaking (NAN) villages Rumba Bakatung, and Sirambana which comprise the Bougainville sample (No. 23).

The official name of the village or villages, approximate altitude, location by coordinates, and major linguistic affiliation are presented in Table 1 for the analysis, village-by-village, of the frequencies of the Gm and Inv phenotypes. The results of the tests on the samples from MN speakers are listed in section A of Table 1 and those from NAN speakers are listed in section B. In each group the villages have been arranged as far as possible in order of their geographic relation to one another.

Gene frequencies, calculated for Gm by means devised for the ABO blood group system (*5*), are shown in Table 2. The individuals comprising the samples were, for purposes of the calculations of gene frequencies, treated as unrelated, though this was patently not the case since as far as possible whole